**Conclusion:** It was shown that the dose distribution and the accuracy of TPS were better when the density of the balloon material was similar to the density of surrounding tissue. Especially when air is inserted into rectum, there is a possibility of difference between actual dose and TPS calculation. Thus, it is needed to look forward to find a method to increase treatment accuracy using tissue-equivalent inner balloon materials.

**EP-1567**

**Investigation of dose buildup region from electron beam by of polymer films and ionization chamber**

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**Purpose or Objective:** The use of the film when it is parallel to the beam axis allows to obtain depth distribution of the dose in water during “single shot” of the accelerator. This method could be useful for characterization of the electron beams of intraoperative accelerators due to the fact that for this modality one needs precise knowledge of the dose depth curve starting from the phantom surface. The use of ionization chamber is routine technique but the spatial resolution of the measured curve is worse. The purpose of this work is to compare depth dose curves obtained using Gafchromic EBT3 film and ionization chamber during experimental investigation and Monte-Carlo simulation.

**Material and Methods:** The experimental comparison of the depth dose curves was carried out using 6 MeV and 9 MeV electron beams of Elekta Synergy accelerator and 6 MeV electron beam generated by compact betatron for intraoperative therapy. The dose distributions were measured by ionization chambers in the water and by Gafchromic EBT3 films in solid phantoms. The film was situated in different geometries, namely along beam axis and across it. The simulation of the process was carried out using PCLab software that allows simulation of the beam interaction with the matter.The first geometry was absorbed dose distribution in pure water that was assumed to be an ideal case. The second geometry assumed film situated along beam axis.The third geometry simulated ionization chamber depth scan. The simulation was carried out for different beam energies assuming monoenergetic beams. In the case of water and film in water it was possible to simulate directly value of dose in water or in the film sensitive layer. In the case of ionization chamber the value of energy lost in the air volume was “measured” as a quantity proportional to dose in water.

**Results:** Results of the simulation and measurement show that the dose depth distributions obtained for water, film and ionization chamber coincides well at depths deeper than maximum dose. In the case of depths from the surface up to maximum the dose “measured” by ionization chamber is larger than the dose “measured” by the film and simulated in pure water. The experimental investigation of the depth dose distribution also shows that ionization chamber overestimates dose values at small depths.

**Conclusion:** Simulation and measurement results show that depth dose distribution from electron beam in water measured by radiochromic film is more precise at small depths than the one measured by ionization chamber.

**EP-1568**

**A Monte Carlo based modelling of a dedicated mobile IOERT accelerator**

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**Purpose or Objective:** Intraoperative Electron Radiation Therapy (IOERT) refers to the delivery of single high dose radiation directly to the tumour bed or residual tumour soon after surgery excision. In this study, a Monte Carlo code was employed to simulate the NOVAC7 electron beams, which is a powerful tool for the simulation of clinical radiation beams and for obtaining detailed knowledge of the characteristics of therapy beams from linear accelerators. The simulation makes it possible to evaluate and calculate all dosimetric relevant necessities such as stopping power ratios, photon contamination and scatter contribution with high accuracy.

**Material and Methods:** The radiation head simulation of NOVAC7 was performed with the EGSnrc user code BEAMnrc. The definite information about the head geometry was given by the manufacturer. Relative absorbed dose measurements, i.e. percentage depth doses (PDDs) and off-axis profiles (OAPs), were carried out using radiochromic films (Gafchromic EBT2, International Specialty Products, Wayne/USA) in a small water phantom type T41023 (PTW-Freiburg, Freiburg/Germany). Specifically measured PDDs and OARs were used to obtain electron energy spectra for different energies (3, 5, 7 and 9 MeV) and applicators (30, 40, 50, 60, 70, 80 and 100 mm). For achieving the measured R50 the most probable energy of Gaussian distribution was varied iteratively in small steps (0.05MeV) around the appropriate nominal energies until a matching of the calculated and measured values of R50 was obtained.

**Results:** Table 1 shows the parameterised data of the PDDs. Calculated Rmax, R80, R50 and Rp are compared with the measured values. For all nominal energies the calculated PDDs agreed within ±2% or ±1 mm with those measured and local percentage dose and distance to agreement are below the required thresholds. The values of the most probable energy and the mean energy of the initial electron beams used as input into the Monte Carlo simulation are reported in table 2 for 100 mm applicator. The results were subsequent evaluated for other applicators. The electron source, incident on the titanium window, was modelled as an isotropic point source with a primary Gaussian distribution on *z* axis. The difference between the mean energy , and the most probable energy , is due to the presence of a low-energy tail in the energy spectrum, which is typical for this type of accelerators.

Table 1: Parameterised data for the PDD comparison between Monte Carlo calculation and film dosimetry at 100 mm field size.

| E | $R_{max}$(mm) | | $R_{80}$(mm) | | $R_{50}$(mm) | | $R_p$(mm) | |
|---|---|---|---|---|---|---|---|---|
| (MeV) | meas. | cal. | meas. | cal. | meas. | cal. | meas. | cal. |
| 3 | 0.50 | 0.55 | 0.95 | 0.96 | 1.24 | 1.25 | 1.35 | 1.36 |
| 5 | 0.70 | 0.80 | 1.32 | 1.31 | 1.71 | 1.70 | 1.94 | 1.93 |
| 7 | 1.10 | 1.15 | 2.00 | 2.00 | 2.50 | 2.50 | 2.95 | 2.95 |
| 9 | 1.40 | 1.50 | 2.50 | 2.60 | 3.20 | 3.20 | 3.83 | 3.88 |

**Conclusion:** This investigation has been performed on a dedicated IOERT mobile linac (nominal electron energies: 3, 5, 7 and 9 MeV). The virtual model was achieved using the EGSnrc Monte Carlo system. The procedure was found to be effective and could lead to the development of a tool to assist the medical physicist during the NOVAC7 commissioning where the amount of dosimetric measurement is time-consuming.

**EP-1569**

**Dose deposition kernel measurements with radiochromic films**

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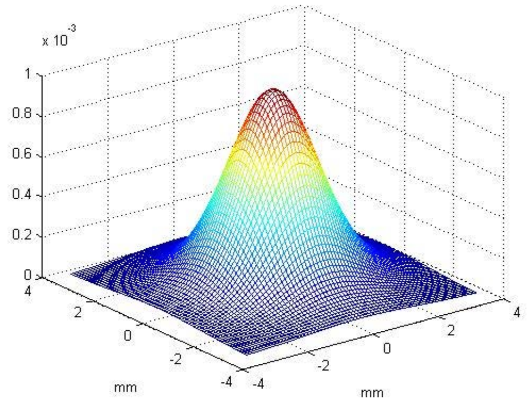
**Purpose or Objective:** In this work we carried out a series of measurements of a small field to investigate the shape of the dose deposition kernel of a radiotherapy beam. Starting with 2D dose distributions measured with radiochromic films a deconvolution process is followed to obtain the dose deposition kernels.

**Material and Methods:** Radiochromic films Gafchromic EBT2 were used to measure 6 MV beams from a Varian Clinac 2100 linear accelerator. The nominal field size of the beams was 0.5 cm x 0.5 cm (at isocenter), and the films were places in a PMMA phantom at 100 cm source to film distance. The dose delivered to the film was 300 cGy. The films were read 6 hours after irradiation with a Microtek ScanMaker 9800XL flatbed scanner. In order to minimize the inhomogeneity variations of the film-digitizer system a procedure, as described in [1] was followed. The procedure uses a number of film cut-outs, taken from one sheet of an RC film, to produce a number of measurements of the same field. After reading the films, the resulting images are registered and averaged. It's worth noting that the film pieces used for the calibration of the film-digitizer response are taken from the same sheet of RC film that the pieces used for dosimetric purposes [1]. In this way, the inter-digitization variability is drastically reduced. Deconvolution of measured dose distributions was carried out by minimizing its Euclidean distance to a calculated dose distribution. The calculated dose distribution was obtained as the convolution of a rectangular aperture with a parameterized kernel,

$$K(r) = k(r) * e^{-p_1 r^2} + p_2$$

where k(r) is the pencil beam dose deposition kernel [2] as calculated by Nyholm [3], p1 describes the radiation source fluence and p2 takes the collimators transmission into account. The optimization algorithm acts on both parameters p1 and p2 through an iterative process.

**Results:** The figure shows the dose deposition kernel obtained after deconvolution.




**Conclusion:** We have determined the dose deposition kernel for a particular set-up: a small field size, 6 MV photon energy and a depth close to dmax. The results obtained show a large lateral spread of the dose, which is responsible for the lack of lateral electronic equilibrium near the edges of the radiation field, and also imposes a constrain in the spatial resolution that portal image systems can reach.

**EP-1570**

**Determination of stopping power ratios and output factors of intraoperative electron beams**

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**Purpose or Objective:** Treatment fields of dedicated Intraoperative Electron Radiation Therapy (IOERT) linacs like NOVAC7 (SIT, Vicenza/Italy) are generated by collimators consisting of PMMA cylindrical applicators. The dosimetry of these electron beams is required to be done under non-reference condition. Therefore, it is necessary that the output factors (*OFs*) and the mass collision stopping-power ratios to be examined carefully. The aim of this paper was to calculate the sw,air (Spencer–Attix stopping power ratios of water-to-air) and *OF* values for electron beams produced by NOVAC7 using a Monte Carlo based model.

**Material and Methods:** The simulation of the radiation head was performed by BEAMnrc Monte Carlo code. For achieving the measured R50 the most probable energy of Gaussian distribution was varied iteratively in small steps (0.05MeV) around the appropriate nominal energies until a matching of the calculated and measured values of R50 was obtained. Based on this Model, the *OF* values were calculated. To compare the calculated *OF* values with experimental data, absorbed dose measurements were performed by a PTW 31014 pin-point ion chamber (PTW-Freiburg, Freiburg/Germany). The phase-space files (files that contain all histories related data e.g. energy, direction, etc.) obtained for the IORT beams were also used as source inputs for the EGSnrc/SPRRZnrc code to calculate the sw,air values.

**Results:** The calculated and measured *OFs* agreed well within the combined uncertainty. The relative differences between calculated and measured *OFs* (see table 1) were up to 3% but agreed better than 1.8% in average. On the other hand this factor increased when decreasing the applicator diameter which is completely dissimilar to other clinical linacs. At smaller field sizes the increased number of scattered events might lead to larger *OF* values. Considering our results presented previously and the combined uncertainty of ±2% in SPR determination, a good agreement was found with TRS-398 dosimetry protocol on the water surface and at zref. The minor discrepancies between Monte Carlo calculation and TRS-398 results are due to the fact that the SPRw,air values are calculated for a dedicated IOERT linac while the Monte Carlo generated values in TRS-398 are based on a variety of linac types.

Table 1, Monte Carlo calculated and measured relative output factors (*ROFs*) for 7 and 9 MeV nominal electron beams for intraoperative radiation therapy. Output factor measurement was performed by a pin-point ion chamber.

| Nominal Energy | Applicator Diameter (cm) | ROF | ROF | Differences (%) |
|---|---|---|---|---|
| | | Calculated | Measured | |
| 7 MeV | 4 | 1.468 | 1.440 | +1.9 |
| | 5 | 1.414 | 1.385 | +2.1 |
| | 6 | 1.347 | 1.309 | +2.9 |
| | 7 | 1.216 | 1.222 | -0.50 |
| | 8 | 1.145 | 1.141 | +0.35 |
| 9 MeV | 4 | 1.609 | 1.567 | +2.68 |
| | 5 | 1.519 | 1.520 | -0.07 |
| | 6 | 1.416 | 1.380 | +2.61 |
| | 7 | 1.261 | 1.241 | +1.61 |
| | 8 | 1.178 | 1.150 | +2.43 |

**Conclusion:** The results considering the *OFs* support the accuracy of the Monte Carlo model achieved. On the other hand, the deviation between the *sw,air* values calculated in this work and those determined using TRS-398 dosimetry protocol changed with the measurement depth in water. It is worth noticing that, one should be aware of such differences working under non-reference condition although they are not significant.